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MINIMUM PERFORMANCE REQUIREMENT FOR AIR FORCE FLIGHTLINE FIRE EXTINGUISHERS:

EXTINGUISHING PERFORMANCE AGAINST 3-DIMENSIONAL AND HIDDEN FIRES

MAY 2002

Approved for Public Release; Distribution Unlimited

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This report contains requirements for extinguishing fires occurring within an engine nacelle through access ports and to extinguish pooled or flowing fuel tail pipe fires. It provides the test protocol and test apparatus requirements for assessing the capability of fire extinguishers to suppress these two specific aircraft engine fires that frequently occur on the flightline. The current Air Force flightline extinguisher uses Halon 1211, an Ozone Depleting Substance (ODS). Any agent used in an extinguisher proposed for testing would be considered a replacement for an ODS. As a replacement under Section 612 of the Clean Air Act of 1990, the agent would have to be approved as an Acceptable Halon 1211 Replacement through the EPA Significant New Alternatives Policy (SNAP) program prior to testing. These criteria are provided for the sole purpose of assessing the capability of fire extinguishers to suppress aircraft engine fires on the flightline.

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

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These criteria are provided for the sole purpose of assessing the capability of fire extinguishers to suppress aircraft engine fires on the flightline.

A following report will be published with an electronic copy of Autocad® files for design drawings and bills of materials for the test fixture and test pad.

1 INTRODUCTION

The current Air Force flightline extinguisher uses Halon 1211, an Ozone Depleting Substance (ODS). Any agent used in an extinguisher proposed for testing would be considered a replacement for an ODS. As a replacement under Section 612 of the Clean Air Act of 1990, the agent would have to be approved as an Acceptable Halon 1211 Replacement through the EPA Significant New Alternatives Policy (SNAP) program prior to testing.

Candidate fire extinguishers to be tested under this requirement must not employ agents that will adversely affect the internal components of Air Force aircraft engines to the extent that extinguishment of "cold start" fires, i.e., small fires within the tailpipe, will require removal of the engine and depot level inspection and/or refurbishment. The engine manufacturers have determined the impact of commonly used fire extinguishing agents and the results included in the pertinent engine maintenance manuals, e.g. Technical Order T.O. 2J-F100-46-2. New agents proposed for this application require evaluation by the OEM to determine if there any detrimental effects on engine components and the results submitted along with the request for testing under this requirement. Final approval for use of the agent rests with the cognizant USAF propulsion engineering authority.

1.1 SCOPE.

This report contains requirements for extinguishing fires occurring within an engine nacelle through access ports and to extinguish pooled or flowing fuel tail pipe fires.

These criteria are provided for the sole purpose of assessing the capability of fire extinguishers to suppress aircraft engine fires on the flightline. They are not the complete criteria for commercial item descriptions, purchase descriptions, and similar documents as they do not cover the totality of operational performance requirements, for example: toxicity, environmental constraints, impact on internal engine components, size, weight, winterization, paint, maintainability, towing, etc.

1.2 BACKGROUND

The Naval Research Laboratory, under contract to the Air Force, conducted an extensive review of flightline fire incidents during the period 1984 through 1990[1]. This review documented the success of flightline fire extinguishers in minimizing the cost per incident of aircraft fires. At that time, incident reports to the Navy Safety Office were inadequate to establish detailed locations of each fire; engine, engine nacelle and APU fires were thought to represent the majority of fires extinguished by flightline fire extinguishers. These data led to the development of the F-100 Engine Nacelle Test Fixture and to improved incident reporting to more fully understand functionality of flightline fire extinguishers.

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[1] Leonard, J. T.; Budnick, E. K.; Rosenbaum, E. R.; Perrault, D. J.; Hayes, E. D., *Flightline Aircraft Fire Incidents and Suppression Agent Effects: Field Inquiries and Incident Analysis*. **Apr 94**; WL-TR-93-3519

Recent research, also conducted by Navy, used the improved incident reports for the period 1993 through 1995 to validate the conclusions of the earlier report[2].

1.3 PURPOSE.

This purpose of this report is to provide the test protocol and test apparatus requirements for assessing the capability of fire extinguishers to suppress two specific aircraft engine fires frequently occurring on the flightline:

a. The extinguisher must effectively extinguish fuel fire in a flowing state (commonly called 3-dimensional or flowing fuel fires) expected in engine tail pipes.

b. The extinguisher must apply agent through engine access ports to penetrate and extinguish fires occurring within the engine nacelle.

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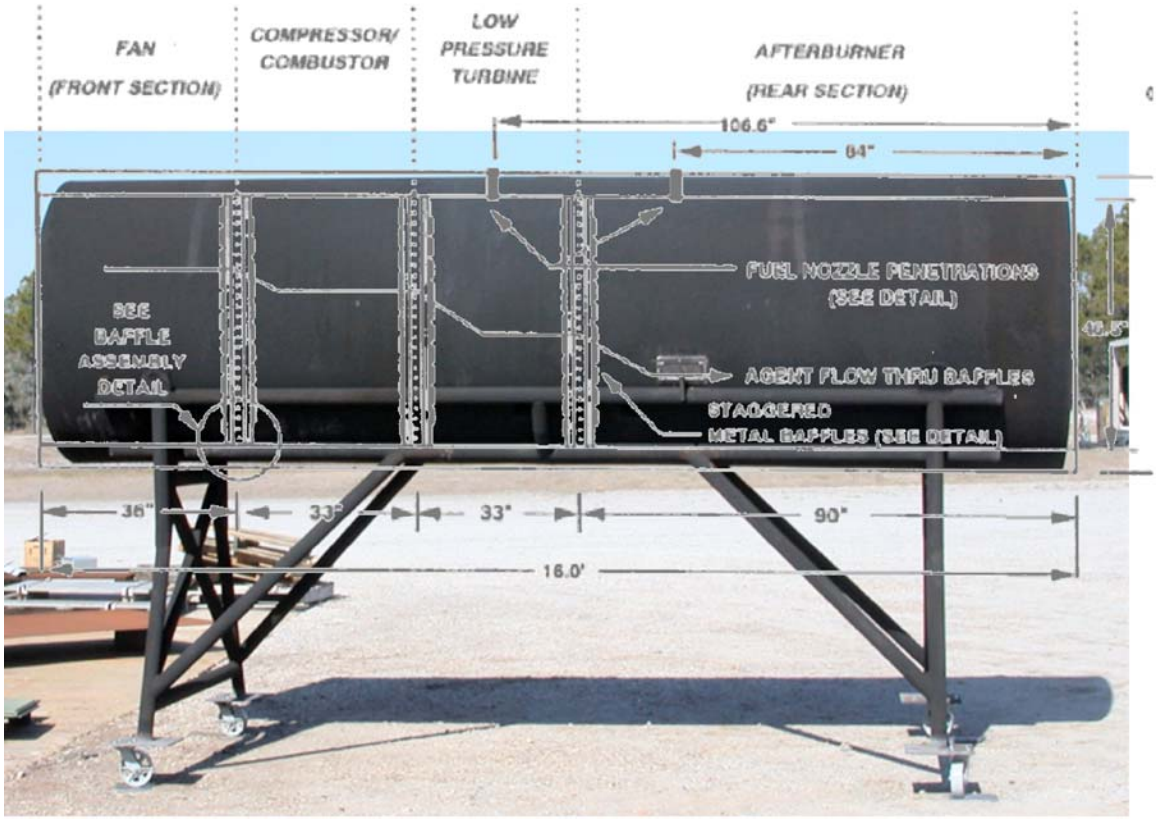
[2] Laramee, S. T.; Verdonik, D. P.; DiNenno, P. J.; Williams, F. W., *U.S. Navy Halon 1211 Replacement Plan Part 2 - Halon 1211 Requirements Review*, **01 Nov 1999**; NRL/MR/6180--99-8411

2 PERFORMANCE TEST PROTOCOL

2.1 F-100 TEST FIXTURE

The test fixture is constructed according to the design provided in Appendix A[3]. Specific features are illustrated in the following figures.

Figure 1. Overall Fixture (Side View)



[3] AutoCAD® files for design drawings and bills of materials for the test fixture and test pad will be published in a following report and have been archived and are available from AFRL/MLQD, 139 Barnes Dr. Suite 2, Tyndall AFB, FL 32403

Figure 2. Aft View F-100 Fixture

The concentric tube design provides the hidden fire space for the Access Panel Test.

Figure 3. Baffle Detail

Two-inch stainless steel strips alternate in two layers four inches apart. Also note the location of the thermocouple used for fixture temperature control.

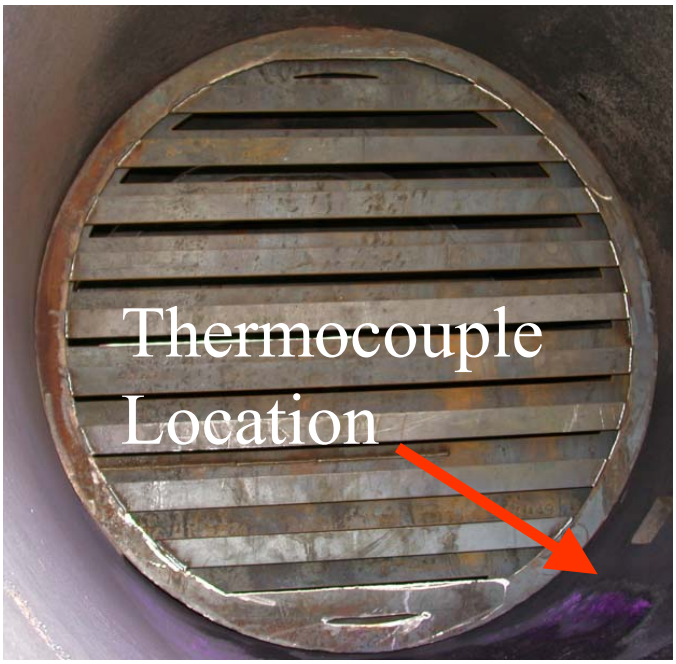


Figure 4. Access Port (Covered)

This configuration is used for the Rear Engine Fire Test

Figure 5. Access Port (Open)

This configuration is used for the Access Panel Fire Test

Figure 6. View Through Ignition Opening

The hole adjacent to the baffle is the position of the #3 fuel spray nozzle

2.2 TEST PROCEEDURES

2.2.1 General Requirements

a. Wind direction: the test apparatus orientation will be adjusted based on the direction of the prevailing wind for that test day. The wind direction shall be from the firefighters back, plus or minus 30 degrees.

b. Wind speed: testing will not commence if wind speed exceeds 8 mph.

c. Thunderstorm: no test will take place when lightning storms are within five miles of the test site.

2.2.2 Rear Engine Fire Test

2.2.2.1 Critical Performance Parameters

- Time to full extinguishment
- Amount of extinguishing agent used

2.2.2.2 Test Specifications

2.2.2.2.1 Required Equipment and Supplies

a. Concave concrete test surface – 11 ft. in diameter, center 3 in. lower than rim.

b. F-100 Test Fixture

c. Thermocouple reading device to monitor fixture temperature during the Pretest phase

d. 50 gal. JP-8 Jet Fuel per test fire

e. Fuel pump with sufficient capacity to supply 4 gpm JP-8 with test nozzles 2 and 3 open

f. Charged test extinguisher

g. Cleanup equipment appropriate for test extinguisher

h. Scale suitable for weighing the extinguisher before and after each test

2.2.2.3 Test Operating Procedure

2.2.2.3.1 Pretest Phase

a. Determine and record extinguisher full weight

b. Ignite afterburner (nozzle 3) fuel spray (JP-8, 2 gpm)

c. Heat tail pipe to 550 ± 25°F

d. Shut off fuel

e. Allow metal to cool to 475 ± 25°F

f. Initiate fuel flow through nozzles 2 and 3 (4 gpm total)

g. Flow 25 gallons of JP-8 through the fixture into the concrete pan

h. If spontaneous ignition occurs, shut off fuel and allow metal to cool to a lower temperature. Return to item f.

2.2.2.3.2 Test

i. Ignite low pressure turbine and afterburner fuel sprays with a suitable torch applied through the ignition port

j. Ignite pan

k. Allow to burn for 15 seconds

l. Apply fire extinguisher according to manufacturers instructions

m. Record

Time to extinguish

Weight of agent used

n. Weigh and record weight of extinguisher after test

2.2.3 Access Panel Fire Test

2.2.3.4 Critical Performance Parameters

- Time to full extinguishment
- Amount of extinguishing agent used

2.2.3.5 Test Specifications

2.2.3.5.1 Required Equipment and Supplies

a. Concave concrete test surface – 11 ft. in diameter, center 3 in. lower than rim.

b. F-100 Test Fixture

c. Thermocouple reading device to monitor fixture temperature during the Pretest phase

d. 50 gal. JP-8 Jet Fuel per test fire

e. Fuel pump with sufficient capacity to supply 4 gpm JP-8 with test nozzle 1 open

f. Charged test extinguisher

g. Cleanup equipment appropriate for test extinguisher

h. Scale suitable for weighing the extinguisher before and after each test

2.2.3.6 Test Operating Procedure

2.2.3.6.1 Pretest Phase

a. Determine and record extinguisher full weight

b. Ignite afterburner (nozzle 3) fuel spray (JP-8, 2 gpm)

c. Heat tail pipe to 550 ± 25°F

d. Shut off fuel

e. Initiate fuel flow through nozzle 1 (4 gpm)

f. If spontaneous ignition occurs, go to 2.2.2.6.2 b.

2.2.3.6.2 Test

a. Ignite access panel spray with a suitable torch applied between the engine shell and nacelle shell at the bottom rear of the fixture

b. Allow to burn for 15 seconds

c. Apply fire extinguisher according to manufacturers instructions

d. Record

Time to extinguish

Weight of agent used

3 PERFORMANCE EVALUATION

An extinguisher is rated as acceptable or unacceptable in **Extinguishing Performance Against 3-Dimensional And Hidden Fires** based on the following criteria:

3.1 PASS FAIL CRITERIA

3.1.1 Rear Engine Test

To attain a single test grade of PASS, the test extinguisher must produce the following results:

e. Extinguishment of the engine fire and pool fire must occur in less than 30 seconds after the beginning of agent discharge

f. No reignition may occur

g. Agent consumed must not exceed 75% of extinguisher capacity

If all three requirements are not met the extinguisher will be given a single test grade of FAIL.

3.1.2 Access Panel Test

To attain a single test grade of PASS, the test extinguisher must produce the following results:

h. Extinguishment of the nacelle fire and any associated pool fire must occur in less than 30 seconds after the beginning of agent discharge

i. No reignition may occur

j. Agent consumed must not exceed 75% of extinguisher capacity

If all three requirements are not met the extinguisher will be given a single test grade of FAIL.

3.2 SCORING

A test series will consist of no more than ten tests total. An extinguisher will be rated as "Acceptable in Extinguishing Performance Against 3-Dimensional And Hidden Fires" based on the following three scores:

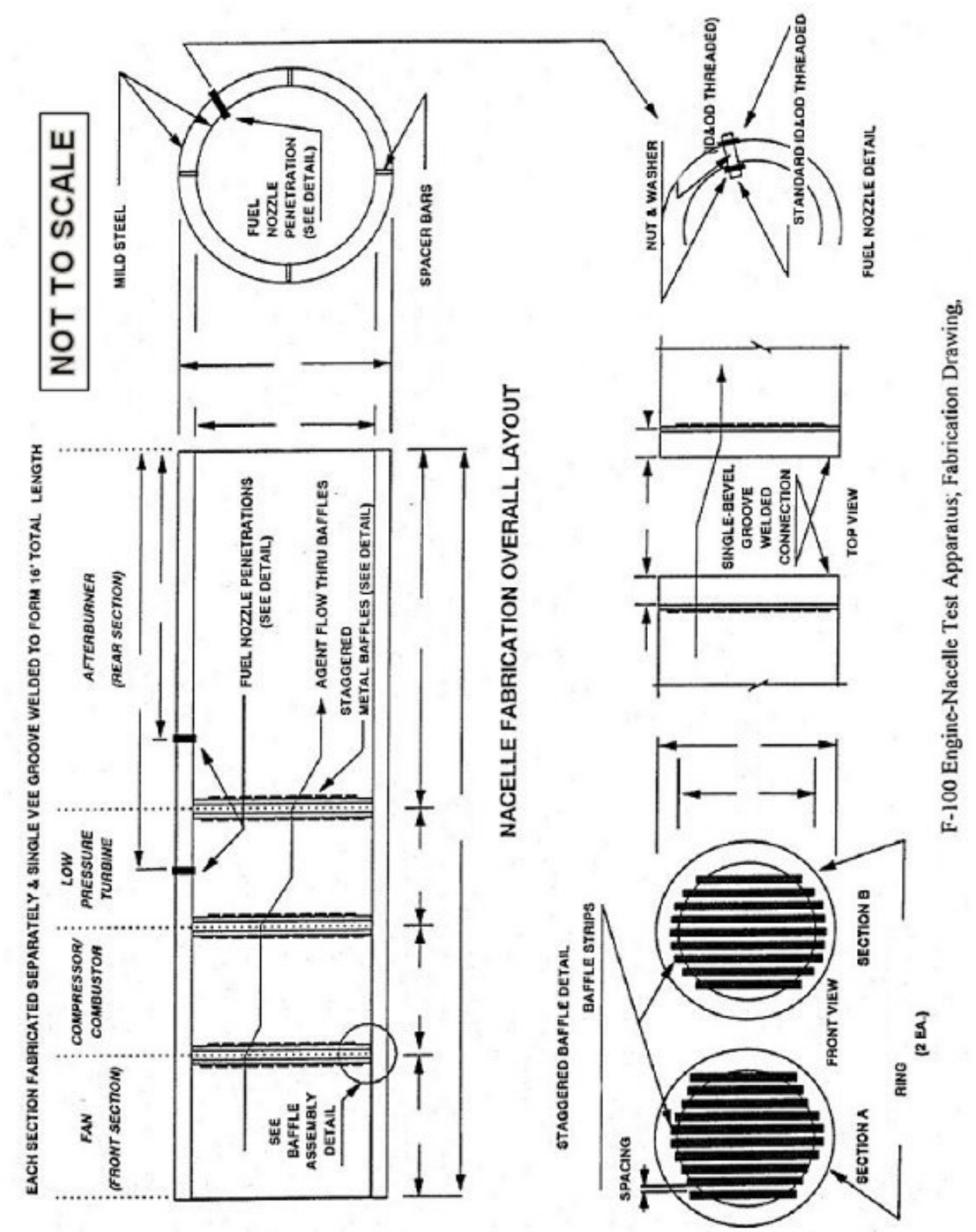
a. Receive a PASS grade on three (3) Rear Engine Tests

b. Receive a PASS grade on three (3) Access Panel Tests

c. Receive a PASS grade on seven (7) tests out of ten tests overall.

Failure to achieve any of these three criteria will result in a rating of "Unacceptable in Extinguishing Performance Against 3-Dimensional And Hidden Fires"

APPENDIX A: F-100 FIXTURE DESIGN



F-100 Engine-Nacelle Test Apparatus; Fabrication Drawing.

APPENDIX B: DATA COLLECTION SHEETS

Test No:	Date:	Time:

Type of Fuel:	JP-8	Fire Scenario:	Flowing fuel	Pool/F100

Pool Fire Size:	100

Fuel Amount:	25	other

Pre-burn Time (sec):	15	Pre-burn Temperature: Pretest	350°F

Agent Type:	Halon 1211

Agent Delivery Syst:	Halon 1211 extinguisher#	Start weight:	End Weight:

Ext. Time (sec):	Timer 1:	Timer 2:

Meterological Data:	Wind Velocity:	Wind Direction:
	Temperature:	Humidity:

Thermocouple Reading:			
Access Panel:	Inside:	Outside:	Ambient:

Observations: